

**From:** Rochlin, Kevin  
**Sent:** Friday, February 14, 2014 12:13 PM  
**To:** Douglas.Tanner; Greutert, Ed [USA]; Kelly Wright; Scott Miller; Stifelman, Marc; susanh@ida.net; Zavala, Bernie  
**Cc:** Rochlin, Kevin  
**Subject:** FW: Comments on the Gamma Study Report  
**Attachments:** RESRAD-FMC Gamma Caprev2.docx; Resrad plotrev3.xlsx

**Follow Up Flag:** Follow up  
**Flag Status:** Flagged

See attached from Barbara Ritchie.

I am planning on doing two things at our March 6 conference call (we still have our call next week on 2/21 as well).

- 1) Have FMC walk through the design submittal
- 2) Discuss gamma cap comments.

I think that we will need two hours for the call and am adjusting the schedule for 9 to 11 on that day.

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As a check on the model information that was used by FMC for the gamma cap, I had Rick Poeton, my rad consultant do a check on the calculations. His report is attached. Bottom line, what FMC did was accurate, the gamma cap should be effective at 12 inches, and as we told FMC in the gamma cap letter, we still need to verify.

Kevin

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From: Barbara Ritchie [BARBARA.RITCHIE@fmc.com]  
Sent: Wednesday, February 12, 2014 10:45 AM  
To: Rochlin, Kevin  
Subject: RE: Comments on the Gamma Study Report

Kevin,

Thank you for sending comments and recommendations on the 11/25/13 Gamma Cap Performance Evaluation Report. As suggested in your transmittal letter, we agree that a conference call is appropriate to discuss our thoughts on options to address the recommendations for additional field work to supplement the efforts last fall, prior to finalizing a response and developing a work plan for that additional field work.

Based on the work schedule (see 1/15/14 monthly report), we're working on the 3/3/14 submittal package - "Soil Remedy - 30% Design Package; Site-Wide Grading and Storm water Design and Plans at the Pre-final (90%) RD level." We anticipate your comments on that package by 5/2/14. The work schedule then has us making any necessary changes and submitting a Final (100%) RD Package for Site-Wide Grading and Stormwater Design and Plans on 6/2/14, so that we then can get in the field for grading and stormwater work by 7/7/14.

With respect to your comments on the Gamma Cap Performance Evaluation Report, I'd propose that we try to schedule the conference call in early March. That would allow us to develop the final response to comments and work plan (Field Mod No. 2?) for the additional gamma cap field work, targeting submittal on or about 4/15, so it won't interfere with your review of the 30% design package (by 5/2/14)....and you could review/comment while we're developing the Final (100%) RD Package for Site-Wide Grading and Stormwater Design and Plans for submittal on 6/2/14.

If that schedule makes sense to you, please suggest some dates when you and your team would be available in early March.

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From: Rochlin, Kevin [mailto:rochlin.kevin@epa.gov]  
Sent: Wednesday, January 29, 2014 3:01 AM  
To: Barbara Ritchie  
Subject: Comments on the Gamma Study Report

See attached.

Kevin

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From:

Kevin Rochlin | Superfund Remedial Project Manager U.S. Environmental Protection Agency | Region 10 Office of Environmental Cleanup  
1200 6th Avenue, Suite 900, ELC-111 | Seattle, WA 98101  
(206) 553-2106  
(206) 553-0124 (fax)  
rochlin.kevin@epa.gov

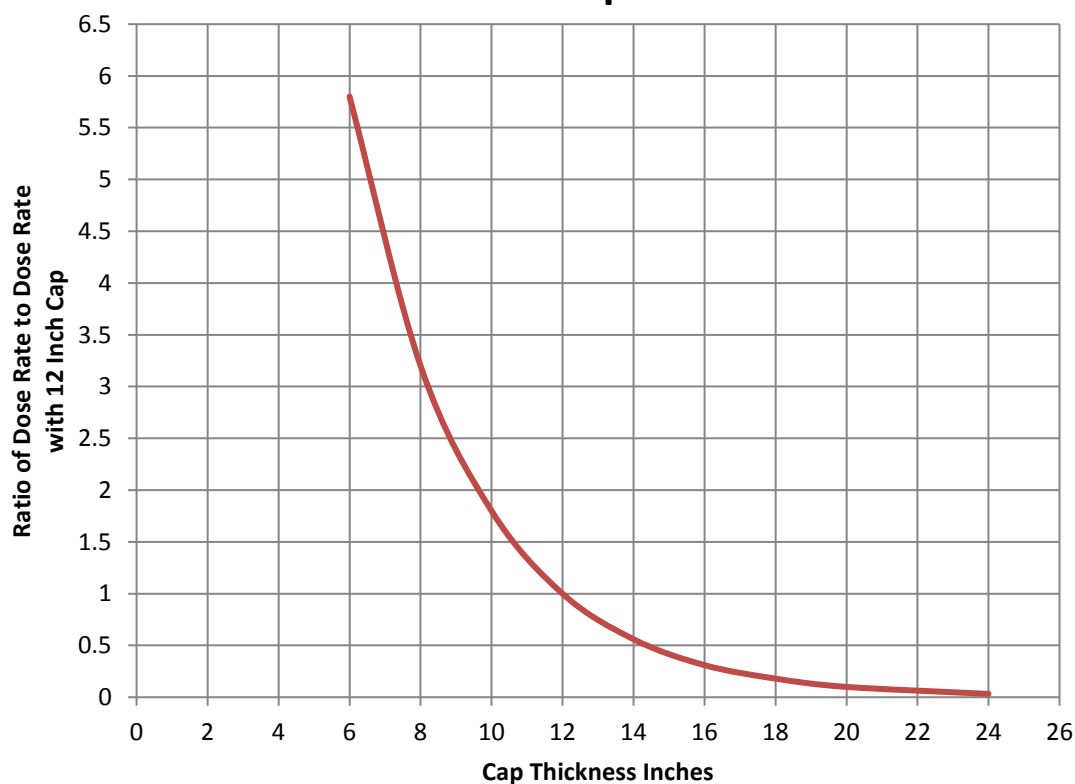
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### RESRAD Calculation: Ratio of Dose Rate to Dose Rate with 12 Inch Cap

Cap (inches)	uR/hr	Dose Rate Ratio to 12 Inches
6	7.65	5.8
8	4.25	3.2
10	2.38	1.8
12	1.33	1
14	0.75	0.56
16	0.42	0.31
18	0.24	0.18
20	0.13	0.1
24	0.03	0.032

### Ratio of Dose Rate to Dose Rate with 12 inch Cap



RESRAD 6.5 calculations using 10,000 m2 source, 37 pCi/g Ra-226, 1.6 g/cc density  
Unshielded dose rate 42 uR/hr

## RESRAD Analyses of Gamma Caps for FMC Slag

R.W. Poeton

The FMC Gamma Cap Test was performed to verify that a cap of 12 inches would be sufficient to meet performance objectives at FMC. For a number of reasons, that test was not successful. To better inform future efforts and as an independent check on the conclusions of the Gamma Cap Model Report, calculations have been performed using RESRAD 6.5 to evaluate the potential effectiveness of various cap thicknesses in attenuating radiation from slag at the FMC site. In some cases comparisons were made to the results of the FMC modeling using the Los Alamos Monte Carlo N-Particle Transport Code (MCNPX), used in the Gamma CP Model Report. The purpose of this analysis is not, however, to compare models in any depth, but to extract some general insights about the application of their results to the practical problems of gamma cap design.

### Slag Dose Rates Without Any Cap

The two models take different approaches to estimating radiation levels and incorporate different assumptions. For an initial comparison, unshielded estimated dose rates were compared. For a slag area of 227 square meters, The MCNPX modeling assumed a Ra-226 concentration of 31 pCi/g and a slag density of 1.9 g/cc. Based on this, a dose rate for unshielded slag was calculated to be approximately 42 uR/hr. RESRAD produced the same result, once adjustments to the source term had been made (assuming 37 pCi/g Ra-226) to account for the different density used in RESRAD.

### Model Assumptions and Estimated Cap Effectiveness

The MCNPX calculations evaluated various thickness of cap. These calculations assumed a dry, sandy soil cover with a density of 1.4 g/cc. It is noted in the Gamma Cap Model Report that actual conditions, such as the addition of moisture and the use of silty clay rather than sand for the cap, would be expected to further decrease radiation levels. Comparison with RESRAD results appear to confirm this expectation. RESRAD methods assume a silty soil, consistent with Federal Guidance Report No. 12, and the RESRAD calculations show that type of cap material to be more effective in reducing radiation levels than the sand assumed in the MCNPX calculations.

Two examples demonstrate this. The MCNPX calculations for a 12 inch cap estimate that the unshielded radiation level of 42 uR/hr would be reduced to 2.86 uR/hr. This is a 93% reduction. Similar calculations using RESRAD estimate that the reduction in radiation level would be 97% using RESRAD methods. This would appear to be a small difference, but it demonstrates that cap effectiveness calculations are sensitive to the makeup of the cap material. Moisture content, elemental composition, as well as density are important factors. RESRAD calculates a 97% reduction from the unshielded slag level to 1.3 uR/hr assuming a 12 inch cap. This result also points out the important fact that relatively small differences in estimated cap effectiveness (97% vs 93%) can result in large relative differences in the residual radiation levels (1.3 uR/hr vs 2.8 uR/hr). As pointed out in the Gamma Cap Model Report, the

MCNPX assumption of a dry sandy cap is a conservative one, and it is possible that actual residual radiation levels on a 12 inch cap would be lower than calculated.

The second example is the estimate of additional reduction in radiation level by using a 14 inch cap rather than a 12 inch cap. The Gamma Cap Model Report calculations estimate a 32% reduction using the extra two inches of cap. RESRAD estimates show a 44% reduction. Again, these comparisons indicate that the Gamma Cap Model Report calculations for cap effectiveness are conservative compared to RESRAD, and potentially to actual field conditions.

#### Calculated Effectiveness of Various Cap Thicknesses

To evaluate the effectiveness of various thicknesses of cap cover, a series of RESRAD calculations were performed assuming various thickness of cap. Results were normalized to radiation levels obtained with a 12 inch cap using RESRAD. For example, a 6 inch cap is estimated to have a residual radiation level 5.8 times higher than a 12 inch cap. From these results it can be seen that RESRAD calculates that a 12 inch cap would reduce radiation levels to 1.3 uR/hr. This is less than half of the 2.8 uR/hr risk-based criterion for cap performance. On this basis, residual radiation levels could still be acceptable even if Ra-226 concentration levels in slag were twice the assumed average levels. The same data also indicates that a cap thickness of 10 inches could be sufficient to meet a 2.8 uR/hr criterion. These conclusions are consistent with the observation that a cap thickness of 12 inches appears to be a conservative value based on RESRAD calculation.

A plot of the RESRAD results also shows that the reduction in radiation level with increasing cap thickness is not linear. There is an inflection point in the neighborhood of 12 inch cap thickness after which there are diminishing returns indicated for additional thickness of cap. In terms of “bang for the buck”, a cap thickness of 12 inches therefore appears to be a cost-effective and practical value.

#### General Conclusions:

It appears that the estimate that a 12 inch soil cover will reduce radiation levels from slag (at approximately 30 pCi/g Ra-226) to acceptable levels is a conservative one based on RESRAD model calculations.

Based on RESRAD calculations, additional thicknesses of cap material (greater than 12 inches) will reduce radiation levels further, but with diminishing effectiveness.

To ensure that performance criteria are met for reduction in radiation levels, model-derived estimates of cap performance must be verified by actual testing. The effectiveness of a given thickness of cap depends strongly on the type of material used for the cap. When significant reductions in radiation levels (e.g. greater than 90%) make thick caps necessary, small differences in cap effectiveness can result in significant relative differences between resulting residual radiation levels. In addition, there is potential for variation in contaminant concentrations across the site. All these factors contribute to significant uncertainty in cap performance in shielding FMC slag.

